Faculty Working Papers

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AND THE QUESTION OF RAILWAY ABANDONMENT

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Transportation Research Paper #4 #203

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An issue of major importance in the transportation field is that of possible abandonment of light traffic railway lines. The Department of Transportation plan for restructuring the northeast railroad system calls for abandonment of several thousand miles of road. Many state governments, communities, and shippers are greatly concerned about the possible loss of rail service.

Like other forms of business activity, the inability to obtain revenues in excess of costs reflects primarily an inability to lower costs below certain levels in response to declines in volume. If operation is profitable at a certain level of traffic volume, and if each successive ten percent decline in volume could be accompanied by a ten percent decline in overall costs, operation would continue to be profitable. While economic analysis suggests that this is not typically possible, little systematic work has been done with railroad cost functions of light traffic lines.[1]

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[1]The primary studies of cost functions of heavy traffic lines are to be found in the work of John R. Meyer, et al., The Economics of Competition in the Transportation Industries (Cambridge: Harvard University Press, 1959); George H. Borts, "The Estimation of Rail Cost Functions," Econometrica, XXVIII: 1 (January, 1960), pp. 108-31; and Ann F. Friedlaender, "The Social Costs of Regulating the Railroads," American Economic Review, LXI: 2 (May, 1971), pp. 226-34.

*The authors are indebted to Mrs. Lynne Levine for performing the regression analysis, to Professors Robert Resek and Thomas Yancey for their assistance, and to the University of Illinois Graduate Research Board for financial assistance.

What is necessary is a more precise knowledge of their cost functions and of the minimum levels, if any, below which costs cannot be reduced.

There are two possible empirical approaches: a cross-sectional analysis relating costs to volume of traffic on lines with differing traffic density, and a time series analysis tracing the reactions of various types of costs to volume over a period of time. This paper presents the results of a cross-section analysis, while subsequent work will consider the time series approach.

It is impossible to obtain data for branch lines of Class I railroads separate from that of the system as a whole from the material that is currently available. The Class II railroads, however, those with annual gross revenues of less than $5,000,000, do provide usable information. These are typically, but not exclusively, light traffic lines. The Interstate Commerce Commission requires detailed information on costs and revenues from these railroads in the Annual Report which they must file. Information from these reports was published by the I. C. C. through 1968 in <u>Transport Statistics in the United States, Section A-II, Abstract of Reports Rendered by Operating Railroad Companies of Class II</u>. Coinciding almost exactly with the time at which interest in this data greatly increased, the I. C. C. ceased compiling and publishing it in 1969. Accordingly, the 1968 data are used in this cross-section analysis because of the laborious task of extracting it from the individual annual reports for a more recent year. For the time series analysis, the data has been brought up through 1973 for a sample of roads.

As of 1968, there were 298 Class II railroads. From this group, several types of lines were omitted

1. Lines operated as integral segments of Class I railroads, including the lines of the Canadian systems in the United States. Separately operated subsidiaries of Class I roads were not excluded.

2. Lines not operating the full year.

3. Lines that were in fact primarily switching and terminal operations, though not so classified by the I. C. C.

4. Lines for which necessary data were not reported or were obviously in error.

5. Roads that were primarily passenger carriers (e.g., Staten Island Rapid Transit).

These criteria resulted in the elimination of 89 roads, leaving a sample of 209 roads.[1] Those remaining vary widely in length and traffic, from such roads as the Atlanta and West Point and the Western Railway of Alabama, basically similar in operation to Class I roads, on the one hand, to the Union (of Oregon), with two miles of line and total annual railway operating revenues of $31,000 on the other. Types of traffic also vary widely; a number are almost exclusively lumber carriers; others handle a wide variety of inbound and outbound freight.

Statistical cost functions for Class II railways were estimated, relating several types of costs per thousand ton-miles to distance (measured as the mileage of each road)[2] and volume (measured in thousands

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[1]Much of the regression work presented in this article was also run using a smaller (116 railroads), presumably more homogeneous, sample. The results obtained for this sample were not appreciably better than those reported here.

[2]The assumption is made that all traffic was handled over the entire length of the road. For these smaller railroads, this assumption is frequently, but not universally, valid.

of ton-miles of freight carried per mile).[1] Ordinary least squares regression methods were used to estimate these relationships. Cost per thousand ton-miles was the dependent variable in each case. Three different models were set up, each with the general form

$$C = C(D, V), \tag{1}$$

where C = cost per thousand ton-miles,

D = distance, and

V = volume.

Model I is linear in both D and V:

$$C = a + b_1D + b_2V. \tag{2}$$

Model II is linear in the logarithms of D and V:

$$C = a + b_1 \ln D + B_2 \ln V. \tag{3}$$

Model III is linear in the reciprocals of D and V:

$$C = a + b_1(1/D) + B_2(1/V). \tag{4}$$

Models II and III were utilized in an effort to introduce nonlinear possibilities into a linear estimation procedure. It was expected that the signs of the coefficients b_1 and b_2 would be negative for Models I and II and positive for Model III, indicating that cost per ton-mile declines as distance or volume increases.

The first relationship estimated included all operating costs (per thousand ton-miles as the dependent variable.[2] Results for the three

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[1]Interstate Commerce Commission, Transport Statistics in the United States: 1968, Section A-11 was the source of all data used in this study.

[2]Operating costs do not include taxes, equipment rentals, or interest. They do include depreciation. The track itself is not depreciated.

models are presented in lines 9 through 11 of Table 1. All regression coefficients were significantly different from zero at the five percent level, as were the coefficients of determination, the R^2s. Some intercorrelation of independent variables exists: the correlations between D and V variables ranged from 0.364 to 0.471 for the three models. However, it was apparently not serious enough to affect the signs of the estimates of b_1 and b_2, all of which were as we had expected. We also checked for heteroskedasticity, using a test developed by Goldfeld and Quandt.[1] In all regressions to be presented in this paper, the data passed the test; i.e., there is no apparent heteroskedasticity.

Models II and III appear to "explain" a much larger proportion of variation in railroad costs in terms of differences in D and V than does Model I, leading us to suspect that the linear formulation of the cost function is inferior to the nonlinear specifications. Indeed this proved true for every set of regressions we ran. For this reason, we have omitted results for Model I throughout the rest of this article.

It is difficult to compare the relative importance of distance and volume to operating costs within and between models in Table 1 because the b coefficients are multiplied by the different variables shown in equations (2), (3), and (4). Our interpretation is therefore delayed until Table 2.

The next phase of this study involved regressing different components of operating costs on the same independent variables, distance and volume.

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[1] Stephen E. Goldfeld and Richard E. Quandt, "Some Tests for Homoskedasticity," Journal of the American Statistical Association, LX: 310 (June, 1965), pp. 539-59.

TABLE 1

Estimated Cost Functions--All U.S.

	Type of Cost	Model	Parameter Estimates*				
			a	b_1	b_2	R^2	D-W
1	C_{1a}	II	181.79	-9.5804	-22.5979	0.3780	1.86
			(13.57)	(-2.59)	(-8.38)		
2		III	16.743	71.082	885.31	.4866	1.88
			(4.16)	(2.06)	(11.85)		
3	C_{1b}	II	59.503	-4.5175	-5.8538	.3124	1.70
			(12.85)	(-3.53)	(-6.28)		
4		III	8.4683	82.576	71.266	.2313	1.75
			(5.23)	(5.93)	(2.37)		
5	C_{1c}	II	225.03	-19.6091	-23.265	.3849	2.01
			(13.94)	(-4.40)	(-7.16)		
6		III	1.7587[a]	410.7	752.53	.6829	2.03
			(0.46)	(12.47)	(10.58)		
7	C_{1d}	II	106.02	-8.3714	-11.0423	.3810	1.89
			(14.21)	(-4.06)	(-7.36)		
8		III	12.444	94.494	268.67	.2686	2.01
			(4.64)	(4.10)	(5.39)		
9	C_1	I	184.18	-0.7244	-0.0746	.1655	
			(13.24)	(-3.26)	(-3.93)		
10		II	565.87	-42.6565	-61.4175	.5125	1.81
			(18.29)	(-4.99)	(-9.87)		
11		III	37.584	668.05	1956.1	.6371	1.86
			(4.25)	(8.80)	(11.94)		
12	E_r	II	49.372	-3.9494[a]	-4.7502	.0906	1.82
			(6.01)	(-1.74)	(-2.87)		
13		III	10.195	24.065[a]	70.421[a]	.0233	1.84
			(3.61)	(0.99)	(1.35)		
14	E_{rt}	II	125.7	-14.0011	-9.1114	.1842	1.86
			(9.18)	(-3.70)	(-3.31)		
15		III	24.93	100.47	218.49	.0886	1.90
			(5.21)	(2.44)	(2.46)		
16	E_{rc}	II	131.67	-9.8375	-15.1754	.2990	1.98
			(11.18)	(-3.02)	(-6.40)		
17		III	-0.5357[a]	165.53	685.94	.6153	1.85
			(-0.20)	(6.67)	(12.81)		
18	E_{rtc}	II	207.99	-19.8892	-19.5366	.3327	1.91
			(12.77)	(-4.42)	(-5.96)		
19		III	14.15	241.94	834.01	.5080	1.91
			(3.06)	(6.09)	(9.72)		
20	C_1+E_{rc}	II	697.54	-52.494	-76.592	.4921	1.94
			(17.42)	(-4.74)	(-9.51)		
21		III	36.998	833.58	2642.1	.6807	1.93
			(3.52)	(9.24)	(13.55)		
22	C_1+E_{rtc}	II	773.86	-62.546	-80.953	.4959	1.92
			(17.78)	(-5.20)	(-9.24)		
23		III	51.733	909.99	2790.1	.6537	1.97
			(4.33)	(8.87)	(12.60)		

*Values of Student's t statistic are given in parentheses beneath each parameter estimate.

[a]Not significantly different from zero at the 5% level.

Source: Calculated from data found in Interstate Commerce Commission, *Transport Statistics in the United States: 1958*, Section A-II

We utilized the same mathematical models as before. The four operating cost components are: maintenance of way costs per thousand ton-miles (C_{1a}), maintenance of equipment costs (C_{1b}), transportation-rail line costs (C_{1c}), and traffic, general, and miscellaneous expenses (C_{1d}).[1] Results of these regressions are presented in lines 1 through 8 in Table 1.

The estimates of b_1 indicate that an increase in distance affects C_{1c}, transportation-rail line costs, most markedly and least affects C_{1a}, maintenance of way costs (for Model III) or C_{1d}, miscellaneous expenses (for Model II). The b_2 estimates indicate that maintenance of way costs are affected most by changes in volume (for Model III), while C_{1b}, maintenance of equipment costs, are least affected. These impressions are largely, but not completely, borne out by the figures in Table 2.

Next, a set of regressions was undertaken relating non-operating cost items to distance and volume. The first dependent variable in this group is rent paid on leased equipment, primarily per diem payments for freight cars,[2] per thousand ton-miles (E_r). This was calculated indirectly from the I. C. C. tabulations as the difference between total operating revenue on the one hand and the sum of total operating expenses, tax accruals, and net operating income on the other.[3] The second variable (E_c)

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[1]Maintenance of equipment includes repair of equipment and depreciation. Transportation-rail line includes wages of train operating personnel, fuel, station expenses, and related items. The final category includes costs of issuance of tariffs, traffic solicitation, and general administrative expenses.

[2]Most Class II railroads do not own their own freight cars.

[3]Rent payments are shown explicitly in the individual railroad reports submitted to the Commission but not in the published I. C. C. tabulations. The I. C. C. records E_r separately from other operating expenses, as is noted above.

in this group is the return on railroad equipment per thousand ton-miles, calculated as the sum of \$300 per mile of track (six percent interest on estimated salvage value of \$5,000 per mile)[1] and a six percent return on investment in other equipment.[2] The third variable (E_t) is tax payments made by the railroads to various levels of government. These are mostly property taxes paid to state and local governments and payments to the national Railway Retirement System, but also include income taxes. Thus, the significance of this item is seriously reduced.

Four sets of regressions are presented utilizing these variables, or combinations of them, in Table 1. Lines 12 and 13 show results of E_r, equipment rentals; lines 14 and 15 E_{rt}, rents plus taxes; lines 16 and 17 E_{rc}, rents plus return on equipment; and lines 18 and 19 for E_{rtc}, rents plus taxes plus calculated return on equipment.

Finally, we estimated a cost function including all operating and rental costs plus return on equipment, $C_1 + E_{rc}$, and then one including these costs plus taxes, $C_1 + E_{rtc}$. Results for these regressions are presented in the last four lines of Table 1.

The regression results in this group vary widely. The level of railroad equipment rentals per ton-mile appears to be independent of road mileage and perhaps of volume as well. This result, which is completely

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[1] This figure was derived from salvage figures in recent I. C. C. decisions relating to abandonments.

[2] The percentage was applied to estimated necessary equipment rather than actual equipment. Necessary equipment, in turn, was estimated by a formula relating equipment investment to total ton-mileage. For example, for less than 200,000 ton-miles, investment was estimated to be \$25,000; 200,000 to 500,000 ton-miles, \$37,500, etc. These figures were built on the basis of motive power requirements for various volumes of traffic.

unexpected, appears to reflect the fact that some Class II roads own far more equipment than they need while the majority own no cars at all. Most own their diesels; some do not. Little systematic variation is likely to be found, therefore, within the class of all smaller roads. The relationship between distance, volume, and rentals plus taxes appears to be almost as weak, partly because of the distributional influence of rentals, partly because property taxes in many states do not vary significantly with distance or volume, being based on capitalization of earnings. E_{rc}, our estimate of a road's return on total capital, is more satisfactory, as are the regressions on E_{rtc}, combining all three variables into one.

The last two pairs of regressions are designed to show the relation between traffic volume and distance and all economic costs--both explicit and implicit--including a normal profit on salvage value. The estimated cost functions for $C_1 + E_{rtc}$, both Models II and III, are diagrammed in Figures 1 and 2 respectively for purposes of comparison. Each curve in the two figures depicts a more or less traditional cost curve, relating average cost per unit of output (ton-miles in this case) to volume, holding road mileage constant. It is clear by inspection that beyond volumes around 100,000 ton-miles per mile, say, costs with Model II are more volume elastic than are those with Model III. The relative distance elasticities are not so clear; the outcome depends upon the level of traffic.

We have made several calculations from these estimated equations as an aid in interpreting them. We invented a hypothetical railroad to make these calculations. It has the median mileage of railroads in our sample, 19 miles, and the median volume, 141,000 ton-miles per mile. We derived the

Figure 1
Average Cost Functions for Class II Railroads
by Distance--Model II

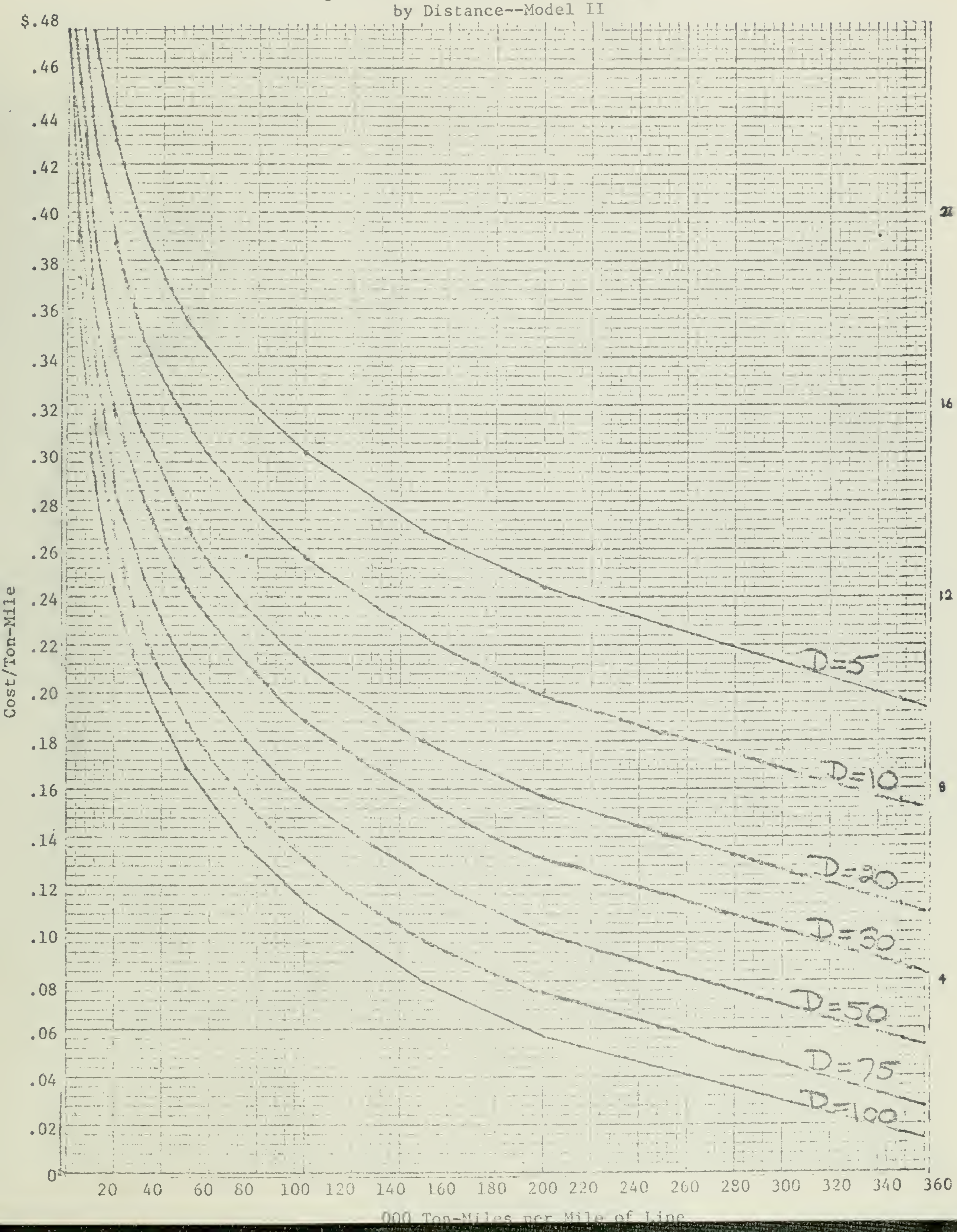
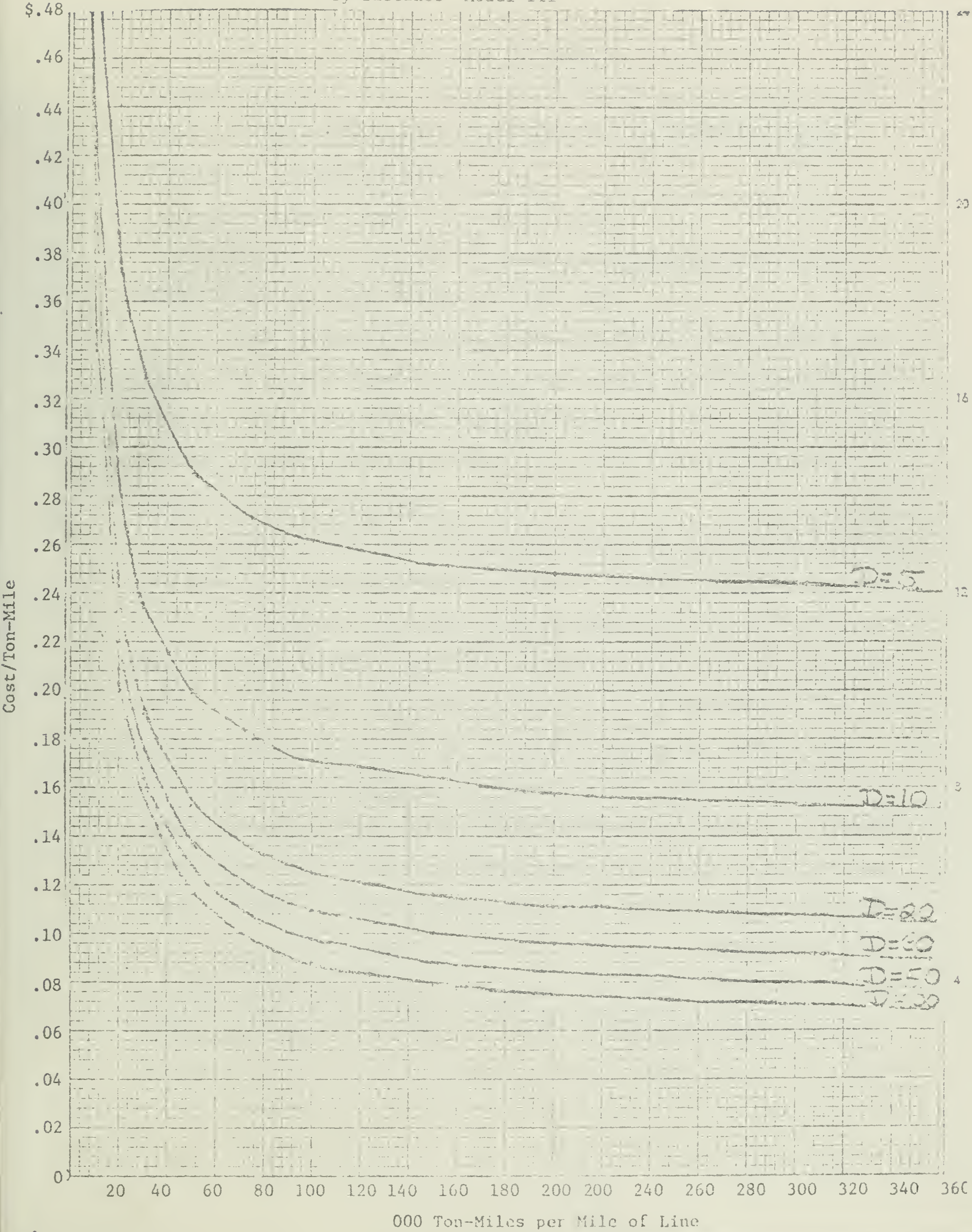


Figure 2
Average Cost Functions for Class II Railroads
by Distance--Model III



cents-per-mile cost and the cost elasticities with respect to distance and volume for each estimated equation in Table 1. The results of these calculations are shown in Table 2.

Several items in Table 2 are worth noting:

1. Costs for the hypothetical road as estimated by Model II are always higher than costs estimated by Model III.

2. Model II costs are always more volume elastic than are Model III costs. The reverse relationship holds for distance elasticities for total costs but not for some of the components of cost. In fact, Model II costs are more distance elastic than Model III costs in about half of the cost components shown in the table.

3. Model II costs are, with but two exceptions, more volume elastic than distance elastic, while the situation is reversed with Model III costs.

4. Maintenance of way costs are very important to Class II railroads. With the lowest traffic lines, these account for well over half the total costs. At the median they constitute about the same percentage of the total as transportation costs (the cost of actually moving the trains). But, surprisingly, the elasticity of maintenance of way costs with respect to changes in volume is the highest of the four expense categories. In other words, while there are certain minimum maintenance costs, outlays for this purpose do rise as traffic volume rises, but of course at a much lower rate.

5. The responsiveness of transportation costs to changes in volume is slightly less than that of maintenance of way costs. The responsiveness of the maintenance of equipment and general-administrative cost categories is much less. The return on investment (salvage value) item is not a major

TABLE 2

Estimated Costs per Ton-Mile and Cost Elasticities for a Median Railroad*

	Type of Cost	Model	Cost per ton-mile	Elasticities: Distance[1]	Elasticities: Volume[2]
1	C_{1a}	II	.0416	-0.2301	-0.5427
2		III	.0257	-0.1400	-0.2337
3	C_{1b}	II	.0172	-0.2626	-0.3403
4		III	.0133	-0.3263	-0.0377
5	C_{1c}	II	.0520	-0.3768	-0.4470
6		III	.0287	-0.7535	-0.1851
7	C_{1d}	II	.0267	-0.3139	-0.4140
8		III	.0193	-0.2575	-0.0982
9	C_1	II	.1360	-0.3136	-0.4515
10		III	.0855	-0.4062	-0.1594
11	E_r	II	.0142	-0.2779	-0.3342
12		III	.0120	-0.1059	-0.0416
13	E_{rt}	II	.0393	-0.3559	-0.2316
14		III	.0318	-0.1665	-0.0485
15	E_{rc}	II	.0275	-0.3573	-0.5512
16		III	.0130	-0.6719	-0.3733
17	E_{rtc}	II	.0526	-0.3776	-0.3711
18		III	.0328	-0.3866	-0.1796
19	C_1+E_{rc}	II	.1636	-0.3209	-0.4408
20		III	.0995	-0.4583	-0.1873
21	C_1+E_{rtc}	II	.1887	-0.3315	-0.4291
22		III	.1183	-0.4014	-0.1649

*The median railroad is 19 miles long and has a volume of 141,700 ton-miles per mile.

[1] The elasticity with respect to distance is b_1/C for Model II and $-b_1/DC$ for Model III.

[2] The elasticity with respect to volume is b_2/C for Model II and $-b_2/VC$ for Model III.

Source: Calculated from parameter estimates in Table 1.

overall item in costs; its responsiveness to changes in volume is somewhat artificial because in part it reflects the formula used in deriving the salvage value.

6. The various cost categories show a surprising responsiveness to differences in distance. As distance increases with a given volume, the various cost items rise though not as fast as distance. This presumably reflects certain economies of scale: a short line cannot utilize its equipment and manpower as effectively as a longer line. Again, even though the response is inelastic, it is by no means negligible.

The second stage of this project involved estimating regional cost functions. Previous work by Borts[1] on Class I railroads indicated that railroads in different regions of the U. S. do have different cost structures. Accordingly, our sample was divided into three regions: Eastern (n = 62 roads), Southern (n = 57 roads), and Western (n = 90 roads).[2] Regressions were run for all dependent variables except $C_1 + E_{rtc}$ for each model for each region. The results are summarized in Tables 3, 4, and 5. These results can be analyzed best by calculating cost estimates for each region for our median railroad and comparing them. These estimates are presented in Table 6.

This table indicates that Class II railroads in the Eastern region do have substantially higher costs, at given volume and distance, than their counterparts elsewhere in the United States. Borts made this same finding for Class I roads.[3] Furthermore, our results show that costs of Class II

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[1]Borts, op. cit.

[2]These regional groupings were established by the I. C. C.

[3]Borts, op. cit.

TABLE 3

Estimated Cost Functions--Eastern Region

	Type of Cost	Model	Parameter Estimates* a	b	b_2	R^2	D-W
1	C_{1a}	II	230.79	-10.033[a]	-31.364	0.5041	1.68
			(8.83)	(-1.25)	(-6.74)		
2		III	20.857	131.06[a]	850.38	.7108	2.06
			(2.30)	(1.44)	(11.05)		
3	C_{1b}	II	74.383	-3.7044[a]	-8.1533	.2779	2.09
			(5.49)	(-1.06)	(-4.00)		
4		III	19.119	75.452[a]	30.807[a]	.0440	2.21
			(3.19)	(1.30)	(0.60)		
5	C_{1c}	II	236.16	-13.575[a]	-27.770	.4875	1.72
			(9.42)	(-1.77)	(-6.23)		
6		III	37.645	172.19[a]	594.38	.4199	1.98
			(3.11)	(1.41)	(5.71)		
7	C_{1d}	II	149.62	-10.407[a]	-17.081	.4430	1.90
			(8.57)	(-1.95)	(-5.50)		
8		III	18.66	186.57	248.27	.2425	2.12
			(2.02)	(2.00)	(3.12)		
9	C_1	II	679.07	-38.99	-81.79	.5672	1.83
			(10.83)	(-2.03)	(-7.33)		
10		III	91.005	595.82[a]	1711.2	.4919	2.16
			(2.95)	(1.92)	(5.46)		
11	E_r	II	74.378	-5.0839[a]	-8.2401	.0859	1.96
			(2.97)	(-0.80)	(-1.85)		
12		III	10.805[a]	91.239[a]	60.034[a]	.0190	2.01
			(0.92)	(0.68)	(0.59)		
13	E_{rt}	II	178.31	-12.947[a]	-17.145	.1773	1.87
			(4.63)	(-1.52)	(-2.50)		
14		III	10.50[a]	276.86[a]	206.73[a]	.0850	1.97
			(1.08)	(1.49)	(1.31)		
15	E_{rc}	II	162.79	-10.511[a]	-21.171	.2928	1.83
			(5.61)	(-1.18)	(-4.10)		
16		III	7.5924[a]	100.49[a]	640.94	.4573	2.02
			(0.66)	(0.86)	(6.46)		
17	E_{rtc}	II	266.72	-22.369[a]	-30.076	.3169	1.79
			(6.36)	(-1.74)	(-4.03)		
18		III	16.285[a]	296.11[a]	797.64	.3758	1.98
			(0.39)	(1.61)	(5.04)		
19	C_1+E_{rc}	II	841.86	-49.501[a]	-102.96	.5332	1.77
			(9.95)	(-1.91)	(-6.84)		
20		III	96.597	691.30[a]	2352.1	.5282	2.11
			(2.55)	(1.79)	(7.09)		

*Values of Student's t statistic are given in parentheses beneath each parameter estimate.

[a]Not significantly different from zero at the 5% level.

Source: Calculated from data found in Interstate Commerce Commission, Transport Statistics in the United States: 1968, Section 1-11.

TABLE 4

Estimated Cost Functions--Southern Region

	Type of Cost	Model	Parameter Estimates a	b_1	b_2	R^2	D-W
1	C_{1a}	II	166.2 (4.80)	-15.992[a] (-1.46)	-15.433[a] (-1.83)	0.2330	1.94
2		III	-5.6489[a] (-0.47)	304.74 (2.23)	1424.5 (2.02)	.3091	1.85
3	C_{1b}	II	46.549 (8.06)	-5.3048 (-2.91)	-3.3973 (-2.42)	.4426	1.79
4		III	2.4095[a] (1.16)	85.424 (3.58)	259.03 (2.10)	.4475	1.68
5	C_{1c}	II	135.36 (9.81)	-16.024 (-3.68)	-10.029 (-2.99)	.5543	1.54
6		III	-0.9474[a] (-0.26)	249.42 (6.06)	1185.4 (5.56)	.7698	1.77
7	C_{1d}	II	68.728 (7.26)	-8.3163 (-2.78)	-4.8296 (-2.10)	.4004	1.86
8		III	1.8296[a] (0.57)	116.82 (3.17)	540.34 (2.83)	.4706	1.91
9	C_1	II	416.74 (8.80)	-45.782 (-3.06)	-33.576 (-2.91)	.4997	1.77
10		III	-2.3032[a] (-0.16)	757.00 (4.56)	3405.0 (3.96)	.6428	1.70
11	E_r	II	35.596 (7.34)	-2.2906[a] (-1.50)	-3.4368 (-2.91)	.3566	2.15
12		III	3.4149 (2.05)	34.775[a] (1.82)	349.44 (3.54)	.4210	2.29
13	E_{rt}	II	84.754 (8.92)	-14.362 (-4.79)	-2.5059[a] (-1.08)	.5100	1.70
14		III	7.9947 (2.42)	165.49 (4.37)	503.62 (2.57)	.5473	1.73
15	E_{rc}	II	72.366 (10.26)	-4.3583 (-1.96)	-7.7923 (-4.54)	.5486	1.95
16		III	1.8518[a] (1.07)	56.205 (2.84)	947.69 (9.25)	.7939	2.26
17	E_{rtc}	II	121.52 (10.54)	-16.430 (-4.52)	-6.8614 (-2.45)	.5794	1.77
18		III	6.4316[a] (1.91)	186.92 (4.85)	1101.9 (5.52)	.7273	1.79
19	C_1+E_{rc}	II	489.11 (9.45)	-50.14 (-3.07)	-41.369 (-3.28)	.5298	1.74
20		III	-0.4514[a] (-0.03)	813.21 (4.66)	4352.7 (4.81)	.6892	1.69

*Values of Student's t statistic are given in parentheses beneath each parameter estimate.

[a]Not significantly different from zero at the 5% level.

Source: Calculated from data found in Interstate Commerce Commission, Transport Statistics in the United States: 1968, Section A-11.

TABLE 5

Estimated Cost Functions--Western Region

	Type of Cost	Model	Parameter Estimates a	b_1	b_2	R^2	D-W
1	C_{1a}	II	131.59 (11.36)	-8.427 (-3.16)	-14.845 (-6.60)	0.4713	2.13
2		III	16.416 (5.99)	-10.457[a] (-0.41)	861.6 (8.64)	.6021	2.01
3	C_{1b}	II	44.801 (7.62)	-4.9376 (-3.64)	-3.3237 (-2.91)	.2940	2.04
4		III	4.9443 (4.19)	68.381 (6.29)	115.79 (2.70)	.6025	2.05
5	C_{1c}	II	268.94 (7.74)	-28.477 (-3.56)	-26.234 (-3.89)	.3483	2.15
6		III	-6.1668[a] (-1.52)	342.44 (9.17)	1551.0 (10.52)	.8761	1.99
7	C_{1d}	II	79.132 (8.27)	-9.3645 (-4.25)	6.0309 (-3.25)	.3531	2.06
8		III	9.6493 (3.63)	104.93 (4.29)	25.753[a] (0.27)	.3021	2.07
9	C_1	II	522.02 (10.47)	-51.211 (-4.16)	-50.154 (-5.18)	.4733	2.16
10		III	23.449 (3.36)	508.8 (7.91)	2562.0 (10.08)	.8554	1.95
11	E_r	II	32.552 (4.80)	-4.7515 (-3.04)	-1.1713[a] (-0.89)	.1436	2.29
12		III	10.151 (5.23)	22.624[a] (1.26)	-44.172[a] (-0.63)	.0193	2.18
13	E_{rt}	II	98.449 (6.24)	-15.463 (-4.25)	-2.6407[a] (-0.86)	.2304	2.26
14		III	28.818 (6.24)	91.702 (2.15)	-49.845 (-0.30)	.0770	2.22
15	E_{rc}	II	145.29 (7.76)	-15.805 (3.66)	13.943 (-3.83)	.3516	2.22
16		III	-2.5384[a] (-1.03)	159.28 (7.02)	905.25 (10.11)	.8433	2.21
17	E_{rtc}	II	211.19 (9.16)	-26.516 (-4.99)	-15.412 (-3.44)	.4105	2.29
18		III	16.129 (3.63)	228.36 (5.58)	899.58 (5.56)	.6934	2.17
19	C_1+E_{rc}	II	667.31 (10.08)	-67.017 (-4.39)	-64.097 (-4.98)	.4592	2.19
20		III	20.910 (2.59)	668.08 (8.99)	3467.2 (11.82)	.8879	2.02

*Values of Student's t statistic are given in parentheses beneath each parameter estimate.

[a]Not significantly different from zero at the 5% level.

Source: Calculated from data found in Interstate Commerce Commission, Transport Statistics in the United States: 1968, Section A-11.

TABLE 6

Estimated Costs per Mile of a Median Railroad
by Region*

	Type of Cost	Model	Region: East	Region: South	Region: West
1	C_{1a}	II	$.0459	$.0427	$.0332
2		III	.0338	.0204	.0219
3	C_{1b}	II	.023[illegible]	.0141	.0138
4		III	.0235	.0087	.0094
5	C_{1c}	II	.0586	.0385	.0551
6		III	.0509	.0205	.0228
7	C_{1d}	II	.0344	.0203	.0217
8		III	.0302	.0118	.0154
9	C_1	II	.1591	.1156	.1228
10		III	.1344	.0616	.0683
11	E_r	II	.0156	.0118	.0128
12		III	.0155	.0077	.0110
13	E_{rt}	II	.0406	.0301	.0398
14		III	.0355	.0203	.0333
15	E_{rc}	II	.0270	.0209	.0297
16		III	.0174	.0115	.0122
17	E_{rtc}	II	.0519	.0392	.0568
18		III	.0374	.0240	.0345
19	C_1+E_{rc}	II	.1861	.1365	.1525
20		III	.1[illegible]18	.0731	.0805

*A median railroad is 19 miles long and has a volume of 141,700 ton-miles per mile.

Source: Calculated from parameter estimates in Tables 3, 4, and 5.

railroads in the Southern and Western regions are quite similar. Again, Borts had these results for large roads.[1] Most of the difference in regional total costs is shown to be caused primarily by difference in costs of equipment maintenance, transportation-rail line, and miscellaneous expenses.[2]

Certain limitations of the analysis require emphasis. First, the operating conditions of the various roads differ widely in such areas as: the frequency of service required, the type of terrain through which the track is laid, wage rates in the area, existing condition of the track and equipment, rental versus ownership of equipment, provision of managerial services free of charge by the owners, etc. Secondly, the use of the broad categories of expenses as reported in the I. C. C. statistics volumes involves the merger of items with very different behavior. Maintenance of equipment, for example, includes both day-to-day repair work and depreciation of equipment. Transportation-rail line includes not only wages of train crews and fuel, but also station and billing expenses. Taxes consist of three major forms which behave very differently: railroad retirement taxes, directly related to wages paid; property taxes, not directly varying with volume; and income taxes, which are related to net earnings and therefore to volume in a progressive fashion. Further work will seek to disaggregate these categories.

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[1] Ibid., especially p. 117.

[2] A partial explanation is that the Southern and Western lines are primarily bulk commodity haulers, with heavier loading per car and less frequent service. Many Eastern roads are carriers of manufactured goods with frequent service required. The upward trend in traffic for Western and Southern lines, coupled with the lag in adjustment of certain costs, is another factor.

Conclusions

Average cost functions for Class II railroads appear to exhibit marked curvature with costs declining as distance or volume or both increase. However, costs are inelastic with respect to changes in distance or volume: as distance or volume increase, costs decrease but by a smaller percentage.

According to Model II, costs will always decline with increasing volume, distance held constant. However, when volume increases in Model III, costs approach an asymptote, namely $(a + b_1/D)$, below which costs will not fall. Analogous comments apply for both models to the effect of increasing distance while holding volume constant except that Model III costs approach the value $(a + b_2V)$ asymptotically. If both distance and volume are increased, Model II's costs fall without limit, while Model III's costs approach the value a as an asymptote. All of these differences occur because of the mathematical forms of the two models.

Additionally, we find there is a significant difference between regions: costs of Eastern railroads are higher than those of the Southern and Western railroads.

The authors have a tentative statistical preference for Model III over Model II, largely because it usually explains more of the variation in railroad costs due to differences in distance and volume.

These findings suggest that attempts by railroads to reduce costs in the face of declining traffic will be of limited success. This is particularly true if Class II railroad costs follow a form similar to that of Model III, because Model III costs are most inelastic with respect to changes in traffic volume.